

A red circular graphic with a white line drawing of a power transmission tower and power lines. The word "Unit" is written in a white script font, and the number "5" is written in a white bold font below it.

Unit

5

Cabling

INTRODUCTION

A cable is an assembly of a number of wires kept side-by-side and twisted or braided together. Cabling is the process of preparing cable and setting up a connection. An electrical wire is a path or way of connecting various accessories. Electrical energy is distributed from the energy meter board to appliances and devices, which consume energy, such as television sets, refrigerators, fans, lamps, etc. For distributing the energy, cabling is done by two or more wires running side-by-side and bonded, twisted or braided together to form a single assembly.

The role of a cable is to carry an audio or video signal from one device to another. Cables do not change the nature of the audio or video signal they carry. They do not convert or process the signal.

A conductor is a wire that carries the signal, while connector is a plug at the end of the cable that connects to a device. Cables are important components of a home stereo or home theatre set-up. If one uses appropriate cables for a job, then one could end up with a super sound or picture quality. If one uses cables that are damaged or junky, one could end up with a lousy experience.

Cabling is a secure and safe way to transmit data from one place to another. In cables, the inner conductor

is secured from the outer surrounding and pressure of earth. Cable insulation or shielding should be hard enough for the protection of the inner conductor. The use of correct data cabling and wiring (also referred to as network cabling and wiring) is imperative for successful business, government and academic network infrastructure installations. Structured cabling design and installation must be done under a set of network standards.

Choice of cabling and wiring system

It is necessary that one makes the right choice, while performing cabling and wiring at workplace. Choice for a cabling and wiring system is based on technical and economic factors. The selection of a cable and wire, primarily, depends on the work to be performed. Secondly, cost may be another factor involved in selecting the type of cable.

There are various characteristics or factors to be considered in cabling and wiring, which are as follows.

Cost of wiring

One of the important factors that must be considered for cabling and wiring is the cost of wiring. It must be economical.

Durability

The cabling and wiring material selected must be durable. Cables and wires selected must meet the required specifications. They must be able to withstand and carry maximum current without overload or damage to an equipment.

Permanency

The cabling and wiring must not get damaged by harsh weather, fumes, dampness, etc.

Accessibility

Panels and junctions used in cabling and wiring must be affordable and accessible when there is a need for alteration, extension or renewal.



Appearance

After cable and wire installation is complete, the wires and cables must be covered and tagged as per safety guidelines.

Mechanical protection

It is important to protect the cables and wires from mechanical damage during usage.

Safety

Safety is one of the most important factors that needs to be considered in cabling and wiring. Always prefer conduit wiring for cabling and wiring.

Maintenance cost

Cabling and wiring system employed must have low maintenance cost.

Load

The kind of cable used depends on the type of loads that consume electrical energy. Small diameter cables cannot be used for heavy loads as they may get damaged.

Types of cable

The cables used may be grouped according to

1. conductor,
2. number of cores,
3. voltage rating and
4. type of insulation used.

Based on conductor

On the basis of conducting material used, cables may be divided into two classes.

- Copper conductor cables
- Aluminium conductor cables

Based on number of cores

On the basis of the number of cores used, cables can be divided into three classes.

- Single-core cables
- Twin-core cables
- Three-core cables

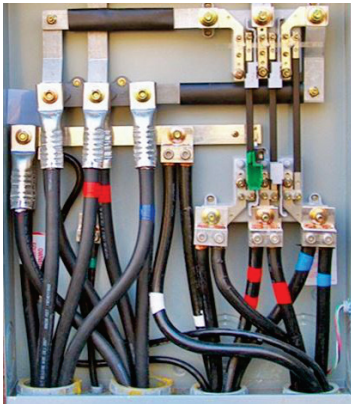


Fig. 5.1 Cabling and wiring

Based on voltage rating

On the basis of voltage rating, cables may be of

- 240/440 volt
- 650/1100 volt

Based on type of insulation

On the basis of insulation used, cables may be categorised as:

- Vulcanised Indian Rubber (VIR) insulated cables
- Tough Rubber Sheathed (TRS) or Cab Tyre Sheathed (CTS) cables
- Polyvinyl chloride (PVC) cables
- Lead sheath cables
- Weather-proof cables
- XLPE cables
- Flexible cords and cables

Cable selection and application

It is essential to know cable construction, characteristics and ratings to understand the problems related to cabling systems. However, additional knowledge is required for assuring satisfactory cable operation. The following are five key factors.

- Cable installation
- Cable construction
- Cable operation
- Cable size
- Shielding

Cable installation

Depending on the distribution system and load, cables can be used for outdoor or indoor installation. After understanding the local site conditions, the maintenance personnel need to ensure that the selected cable system will operate satisfactorily in the desired installation site.

Many times, due to incorrect pulling tension, insulation gets damaged or weakened during installation. Therefore,



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designs of conduit systems are used to minimise the number of conduit bends.

Appropriate bend radius must be maintained in order to avoid unnecessary stress point. After completion of installation, routine inspection, testing and maintenance must be carried out on a regular basis to check the upkeep of the cable system.

Cable construction

Cable construction involves conductors, cable arrangement, insulation and finish covering. Selection and application of cable involves the type of cable construction needed for a particular installation.

Conductors

Conductor material, such as copper and aluminium, are used for power distribution.

Cable arrangement

Cables can be arranged in the following way.

- Single conductor cable
- Three conductor cable

Single conductors are easier to install and splice, and allow the formation of multiple cable circuits. Overheating of the cable must be prevented.

Insulation and finish covering

The selection of cable insulation and finish covering is normally based on the type of

- installation,
- ambient operating temperature,
- service conditions, and
- load served.

Cable operation

In normal and abnormal operating conditions, insulation of the cable must be able to withstand voltage stresses. Therefore, cable insulation must be selected on the basis of applicable phase-to-phase voltage and general system.

Cable size

The selection of cable size is based on these factors.

- Current carrying capacity
- Voltage regulation
- Short circuit rating

The above mentioned factors must be considered before selecting a cable size. In many instances, voltage regulation and short circuit rating factors are overlooked. This can cause danger to a property and personnel, as well as, damage to the cable.

Current carrying capacity

It is the amount of current, which a cable can carry safely. The current carrying capacity of a cable is also based on its thermal heating.

Voltage regulation

Voltage regulation defines the voltage rating of the cable and wire.

Short circuit rating

It is the rating on components and assemblies representing the maximum level of short circuit current that a component can withstand.

Shielding

When working with medium voltage, a cable should be selected based on shielded or non-shielded type. The conditions under which shielded cable is to be selected and applied are explained in the following paragraphs.

The application of shielded cable involves the following considerations.

- Type of insulation system
- Whether the system neutral is grounded or ungrounded
- Safety and reliability requirements of the system

In power systems, where electric field is intense, such as in case of high and medium voltage, surface discharges will take place and cause ionisation of air

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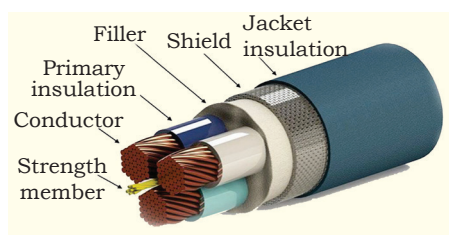


Fig. 5.2 Power cable internal interfacing

particles. The ionisation of air particles causes ozone generation, which can damage certain insulations and coverings. To prevent this shield, cables are used.

There are five fundamental constituents that make a cable—conductor, insulation, shield, filler and strength member (Fig. 5.2).

Commonly used cables

LT (PVC or XLPE) cable

Low tension (LT) cables are heavy duty cables. These are used for working voltage from 650 to 1100 Volt.

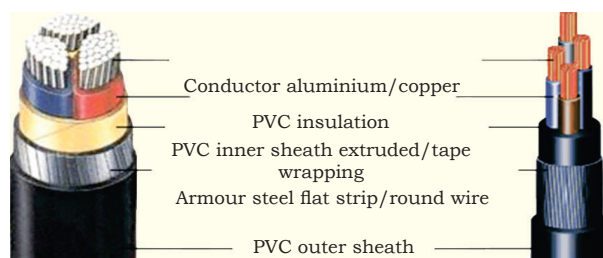


Fig. 5.3 LT cable of three and four cores

These cables are used for underground, as well as, overhead transmission of electric power. These power cables are used in power plants, industries, interconnection of process control, communication and panel control systems, projects and all other electrical installations [Fig. 5.3 (a and b)].

PVC

Polyvinyl chloride (PVC) is a thermoplastic material. It is used for making power cables. It acts as an insulator and can be used for covering the conductor in the cable.

XLPE

Cross linked polyethylene (XLPE) is the most commonly used thermoset material. It is used for making power cables. It acts as an insulator and protecting cover for the power cable.

PVC or XLPE

Single core	Red, black, yellow or blue
Two cores	Red and black
Three cores	Red, yellow and blue
Four cores	Red, yellow, blue and black
Five cores	Red, yellow, blue, black and grey
Six cores and above	Two adjacent cores blue and yellow, and remaining grey



Construction of LT power cable

Conductor: Aluminium or copper

Insulation: PVC or XLPE

Inner sheath: PVC

Armour: Galvanised steel wire or strip

Sheath: PVC

PVC	XLPE
Polyvinyl chloride	Cross linked polyethylene
Under short circuit conditions, it can withstand temperatures up to 160 degrees Celsius.	Under short circuit conditions, it can withstand temperatures up to 250 degrees Celsius.
Low moisture resistance	High moisture resistance
Low overloading capacity	High overloading capacity

Coaxial cable

Coaxial cable is used to carry radio frequency signals and is widely used in the communication system. It is mostly used as it is shielded from external electromagnetic field interference. When carrying high-frequency signal, these cables do not radiate signal in the medium. No leakage of signal is possible because of shielding in the coaxial cable (Fig. 5.4).

Coaxial cable consists of an inner wire called core, which is surrounded by a second wire and the braid that encloses it entirely. But these two wires are electrically isolated from each other. Various types of coaxial cable are available with single or multi stranded cores. The outer sheath may consist of a solid tube, or in most cases, a conductive sheath made of braided wires (hence, the outer sheath is often referred to as the braid) or foil tape (Figs. 5.5 and 5.6).

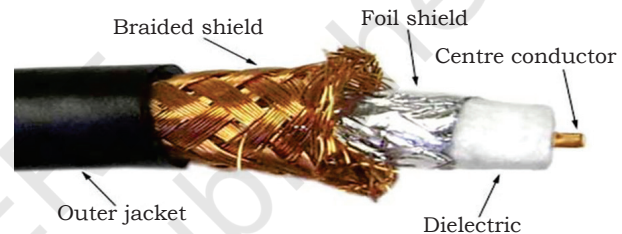


Fig. 5.4 Coaxial cable internal interfacing

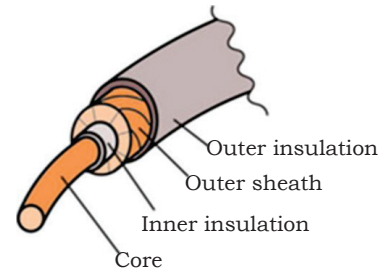


Fig. 5.5 Insulation layers of coaxial cable



Fig. 5.6 Coaxial cable

Optics fibre cable

Fibre optics is the science of light transmission through fine glass or plastic fibre. Optics fibre cables (Fig. 5.7) have various applications due to their inherent advantage over copper conductors.

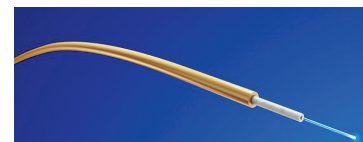


Fig. 5.7 Optics fibre cable

These cables are available in single mode and multi mode.

- Single mode optics fibre cables have a small core diameter (i.e., around 8–10 micrometre) through which only one ray of light can be transmitted.
- Multi mode optics fibre cables have a wider core diameter (i.e., around 50–100 micrometre) through which one or more rays of light can be transmitted.

Colour coding and marking

For a wireman, it is important to be able to identify wires on the basis of colour. By looking at the wire colour, the person can identify the phase, neutral and earth wires. Therefore, the wireman needs to understand the colour coding of wires. Colour coding of a wire represents the purpose for which it is to be used (Fig. 5.8).









	Single Phase	Three Phase	Code	Wire colour
Phase Conductor (Line)			B	Black
	Red or 	Line 1 Red 	P	Pink
	Yellow or 	Line 2 Yellow 	BR	Brown
	Blue	Line 3 Blue	R	Red
			G	Green
			SB	Sky blue
			GR	Grey
			SI	Silver
			L	Blue
			V	Violet
			LG	Light green
			W	White
			O	Orange
			Y	Yellow
Neutral Conductor				
	Black			
Protective Conductor (Earth)				
	Green and yellow			

Fig. 5.8 Colour code for electrical wires

The wireman must be aware of the specifications of the wires, printed on the outer sheath of the cable. The specification on the outer sheath indicates the type and size of the wire. Wires of different colours present inside the sheath serve different purposes.

Black wire

It is used for neutral wire.

Red wire

It is used as phase wire. It contains line voltage and is also called 'hot' or 'line' or 'live' wire.

Yellow wire

It is used as phase wire. It contains line voltage, and is also called hot or line or live wire. Generally, it is included in three-phase supply.

Blue wire

It is also used as phase wire. It contains line voltage and is also called hot or line or live wire. Generally, it is also included in the three-phase supply.

Green wire

Green or green with yellow stripe wires are used as earth wire.

Routing cables

It is the way of placing cables. Routing protect the cables from harsh weather conditions. Fig. 5.9 shows the routing of cables. While routing cables, one must do the following.

- Route the cable to the longest distance first.
- Use the diagram to plan the routing of the cables.
- Cut the unlabeled cable. Label all cables before routing them, else one may lose track.
- Make sure that the cable is not stretched or pinched.
- Make sure to leave the corners of the cable uncut. One must leave ample slack.
- Use electrical tape to attach the two cable ends and the end of the pull string together.

Bending of cables

Bend radius is the minimum radius at which one can bend a cable without making any kink or causing damage. The smaller the bend radius, the greater will be the flexibility of the material. Fig. 5.10 represents the bending of cables.



Fig. 5.9 Routing of cables

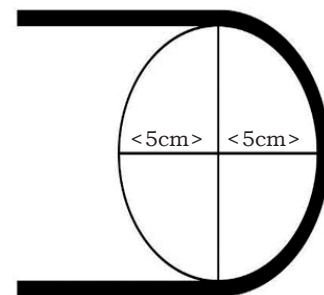


Fig. 5.10 Bending of cables

The minimum bend radius is of utmost importance at the time of handling optics fibre cables. The bending radius varies with different cable designs. If no minimum bend radius is given, a minimum low stress radius not less than 15 times of the cable diameter is assumed to be safe.

The following table represents minimum permissible bending radius of different cables.

Table 5.1: Bending radius of different cables

Voltage rating (kV)	Paper insulated lead cables (PILC)		Polyvinyl chloride (PVC) cables		Cross linked polyethylene (XLPE) cables	
	Single core	Multi core	Single core	Multi core	Single core	Multi core
	Micrometre (μm)	Micrometre (μm)	Micrometre (μm)	Micrometre (μm)	Micrometre (μm)	Micrometre (μm)
Up to 1.1	20 μm	15 μm	15 μm	12 μm	15 μm	12 μm
1.1 to 11	20 μm	15 μm	15 μm	15 μm	15 μm	15 μm
Above 1.1	25 μm	20 μm	20 μm	15 μm	20 μm	15 μm

Assignment 1

1. Identify different types of cable, i.e., PVC, coaxial cable, optics fibre cable.
2. Use stripping tools to strip these cables and identify the material used for making the cables.
3. Discuss the application of these cables.

Check Your Progress

A. Multiple choice questions

1. Thickness of the layer of insulation on the conductor in cables depends on _____.
 - (a) reactive power
 - (b) power factor
 - (c) voltage
 - (d) current carrying capacity
2. Which of the following protects a cable against mechanical injury?
 - (a) Bedding
 - (b) Sheath
 - (c) Armour
 - (d) None of the above



3. Which of the following insulation is used in cables?
 - (a) Varnished cambric
 - (b) Rubber
 - (c) Paper
 - (d) All of the above
4. PVC stands for _____.
 - (a) Polyvinyl chloride
 - (b) Post varnish conductor
 - (c) Pressed and varnished cloth
 - (d) Positive voltage conductor
5. Which of the following colour codes is used for live wire?
 - (a) Grey
 - (b) Red
 - (c) Green
 - (d) Black
6. In cables, sheaths are used to _____.
 - (a) prevent the cable from moisture
 - (b) provide strength
 - (c) provide insulation
 - (d) None of the above
7. Material used for armouring on the cable is _____.
 - (a) steel tape
 - (b) galvanised steel wire
 - (c) Both (a) and (b)
 - (d) None of the above
8. Which colour wire is used as neutral?
 - (a) Red
 - (b) Black
 - (c) Green
 - (d) White
9. Which colour wire is used as earth?
 - (a) Red
 - (b) Black
 - (c) Green
 - (d) White
10. Which cable uses light for transmission?
 - (a) Coaxial cable
 - (b) Optics fibre cable
 - (c) PVC cable
 - (d) XLPE cable

B. Fill in the blanks

1. Green or green with yellow stripes is used as _____ wire.
2. Blue wires are also used as hot wires. They contain line voltage and are also called _____ wire.
3. Black wire is used for _____.

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4. _____ optic cables have very narrow diameter core (i.e., around 8–10 micrometre).
5. Coaxial cable is commonly used to carry _____ signals.
6. Low-tension cables are heavy duty. They are used for working voltage from _____.
7. _____ is the most common thermoset material used as protecting cover of power cable.
8. Multi core optics fibre cable has a wider diameter core, i.e., around _____ micrometre.
9. Fibre optics is the science of _____ transmission through a very fine glass or plastic fibres.
10. Cross linked polyethylene is the most commonly used _____ material.

C. State whether the following statements are True or False

1. Bend radius is the minimum radius at which one can bend a cable without making any kink or causing damage.
2. In selecting and applying cables at medium voltage, a major consideration involves whether the cable should be shielded or non-shielded.
3. Many times, cable insulation is damaged or weakened during installation by applying incorrect pulling tension.
4. Conductors, such as copper and aluminium, are used for power distribution.
5. Coaxial cable is used for radio communication.
6. Black wire is used for earth.
7. Red wire is used as neutral wire.
8. Green wire is used for earthing.
9. PVC is not used as an insulator in wire.
10. Optical fibre uses light as a medium of transmission.

D. Short answer questions

1. List the various types of cable.
2. What is a PVC power cable?
3. What is XLPE power cable?
4. Write the difference between PVC and XLPE power cable.
5. What do you understand by colour coding of cables?
6. What is the importance of bending in cabling?
7. On what factors does the cable size depend?
8. What is optics fibre cable?
9. Define single core and multi core fibre cable.
10. Which factors affect cable selection?
11. What steps must be followed for cable routing?